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Survey on Metal Detectors and Various Methods to Extract Features

Laximi S. Kharangate
Microelectronics Electronics and Telecommunication Department, Goa College of Engineering, Goa, India

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Abstract— In today's world, it is very important to see that the food products we consume are free of any contamination from metal. To ensure this, the need for metal detector is on rise. In this paper, we will see various metal detectors which are present in today's world, and briefly describe the metal detector for the food industry. We will see the different methods which can be used in order to extract features .The simulation in this paper will be done using MATLAB.

Keywords— Metal detector, electromagnetic induction, PLL

I. INTRODUCTION

A metal detector detects the presence of metal nearby. It is an electronic instrument. Metal inclusion hidden within objects or metal objects which are buried underground can also be found out using metal detectors. Metal detectors are used in landmines, food industry, etc. Metal detectors can work on different technologies.

Metal detectors has wide range of applications in pharmaceutical, textiles, plastics, lumber, food, mining, beverage, chemicals and packaging industries. Metal detectors are integrated in production line for major safety issue in the food industry due to contamination of food by metal shards from broken machinery during manufacturing process.

One of the most common foreign materials found in the food is metal. It can be a safety hazard to consumers although it is unintentionally introduced to the food products.

II. STUDY ON DIFFERENT METAL DETECTORS

There are metal detectors used in various industries as said above. Now we will look how they are used in that particular industry.

1. Metal Detectors in Garment Industry

Metal detection is an essential part of the production process in garment industry. The garment manufacturers consider metal detector as very important. A buyer recommends that all the export products must be metal detected. Metal detector helps during the production stage, therefore all products are harmless and free from metal contaminants.

The most effective detection system is Tunnel conveyor system and buyer recommends their use for all apparel. When there is knowledge or suspicion of locating a metal fragment Hand-held and static metal detectors are only acceptable. There are only two types of tunnel conveyor metal detectors. Those which detect ferrous metals and those which detect all metals. All machines have an audible alarm with automatic belt stop when metal is detected.

2. Pulse Induction Based Metal Detector for landmine detection

From [5] we see how the authors of the paper have developed a metal detector for landmine detection using the spatial and temporal features of metal detector response mounted on a mobile robot for autonomous landmine detection. The algorithm is experimentally evaluated on a dataset collected from a test site containing surrogate mines (metallic spheres) and clutter targets.

Pulse induction systems use a single coil as both transmitter and receiver, or they may have two or even three coils working together. This technology will send powerful, short bursts (pulses) of current through a coil. Every pulse will generate a brief magnetic field. When the pulse ends, the magnetic field will reverse polarity and collapse very suddenly, resulting in a sharp electrical spike. This spike lasts a few microseconds. It causes another current to run through the coil. Another pulse is then sent and the process repeats.

3. Pulse Induction Metal detector using PCA And Wavelet Transform

From [6] we can see how the first algorithm by combining Principal Component Analysis (PCA) and Continuous Wavelet Transformation is used in order to determine the position of metallic object as it approaches the detector coils, and the second algorithm which is based on signal filtering in order to characterize object size.

From the results we can see that maximum of two periods are enough in order to obtain good resukts for measuring time intervals and the energy content of the signal. It will reduce the time spent by the algorithm. Also the energy measured show that the PI metal detector contains information related to metallic object size in the acquired signals.

III. METAL DETECTOR FOR FOOD INDUSTRY

In this paper we have discussed the metal detector for food industry in brief. To minimize the amount of metal pieces in food products metal detection is widely used. We see many cases where people suffer when they consume food contaminated with metal. From these examples, motivation for metal detection is initiated. By developing metal detectors we can reduce the expenses of contaminating food articles, which is one of the motivating factors for developing metal detectors.

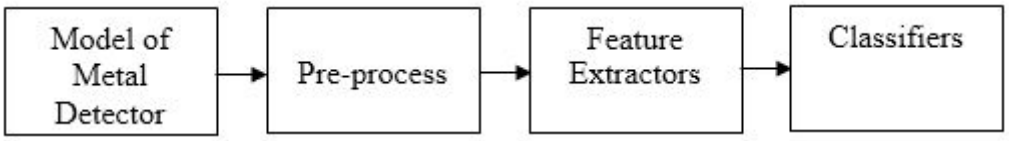

Fig.1.Flow of Metal Detection Analysis

A metal detector is based on the principle of electromagnetic induction. They contain one or more inductor coils. When metal is placed in close proximity to the varying magnetic field, current is induced in the metallic part. These currents are called as eddy currents. The eddy currents will induce their own magnetic field. Now when the electromagnetic field falls on the metal piece, it will get distorted and hence its amplitude, phase and frequency will be altered. These features of amplitude and phase are extracted from the received signal from the metal detector and classification will performed further.

A. Model Of Metal Detector

It consist of one transmitter coil and two receiver coils. The transmitter coil generates a constant electromagnetic field. When a metal particle passes the detector it interferes with the electromagnetic field, causing the signal to be detected by the receiver coils. The electronic unit in the metal detector analyses this signal, evaluates it and signals a metal contamination. It will start with simulation of input data on MATLAB.

The model we referred is from [1].The transmitted input signal and the received signal we get in MATLAB simulation is matched with the signal on the hardware of the metal detector output.

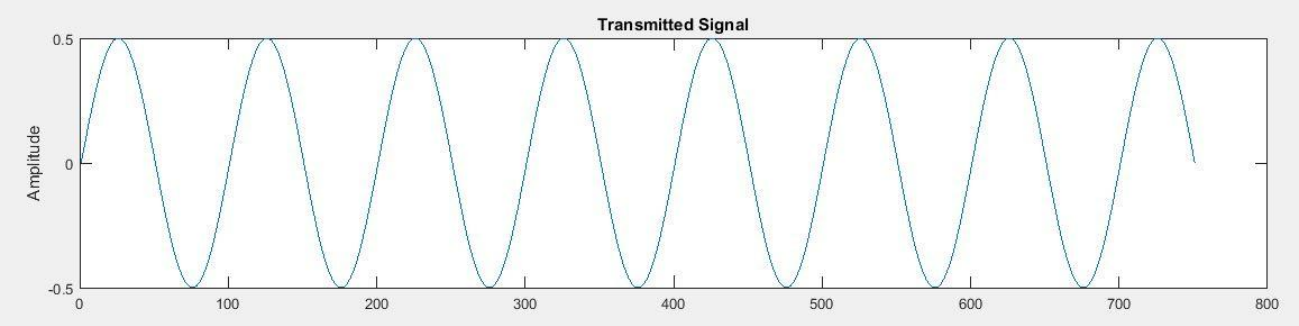

Fig. 2 Transmitted signal

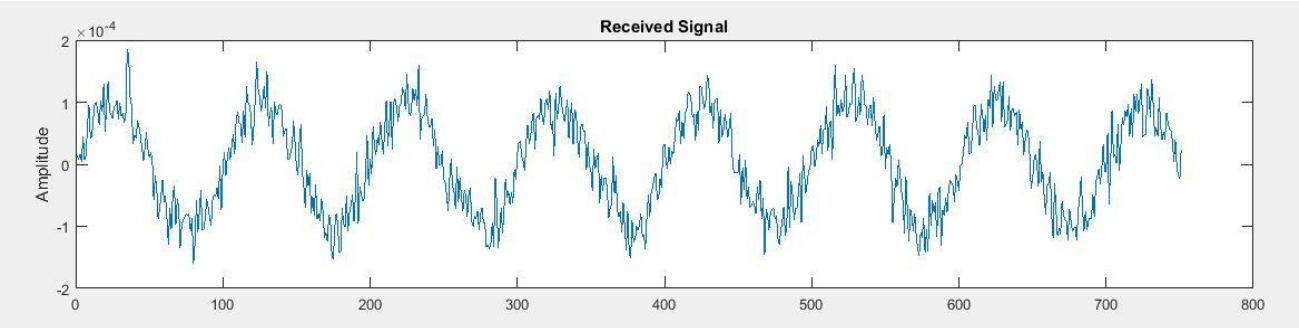

Fig. 3 Received signal

The above two graphs shows the transmitted signal which will be transmitted by the PLL synthesizer [1]. The signal Fig 2 shows the received signal when a metal or pure product is detected within the metal detector. Both the signal are of certain frequency and amplitude. The Transmitted signal is of 150 kHz i.e. the starting frequency. We vary the frequency according to the product. Increasing the transmitting frequency will have a significant impact on the signals, which will originate from the metal detector. But performance can be improved by increasing the transmitting frequency.

From the received signal i.e. output voltage, unique phase and amplitude of metals is observed from the metal detector.

The phase and amplitude for different metals are the features which are to be determined so as further classify the metal and non-metal.

B. Pre-Process

1. Determining Phase and amplitude Theoretically

In order to determine the phase and amplitude theoretically, we see different methods and see which gives the least SNR and choose the best out of it.

i. The RGN-GCMA Method [2]
ii. The FAPES Filter Method [3]
iii. The LMMSE Filter Method [4]
iv. The DFT Method

The SNR ratio of each is tabulated below

Table I SNR measurements

Method	**SNR[dB]**
RGN-GCMA	-9
FAPES	-11
LMMSE	6
DFT	-11

Therefore from above we see that DFT and FAPES gives the least SNR. And hence we extract features i.e. amplitude and phase through these methods.

2. Determining Phase and amplitude through ADC

The other way to determine the phase and amplitude is through ADC conversion. The received signal is passed through the LPF, which in turn is given to microcontroller to the ADC port. The ADC port will the values in form of I and Q in volts.

The ADC Values are then converted to I and Q using the ADC conversion formula.

I,Q =Value*3.3/4096

These I and Q values are then converted to amplitude and phase using the Quadrature Demodulation theory.

C. Feature Extractor

The extracted features are in the form of amplitude and phase which can be further used to classify a metal and a non-metal studying its characteristics.

Once we get the amplitude and phase, the graph will look like as shown below (simulation done in MATLAB)

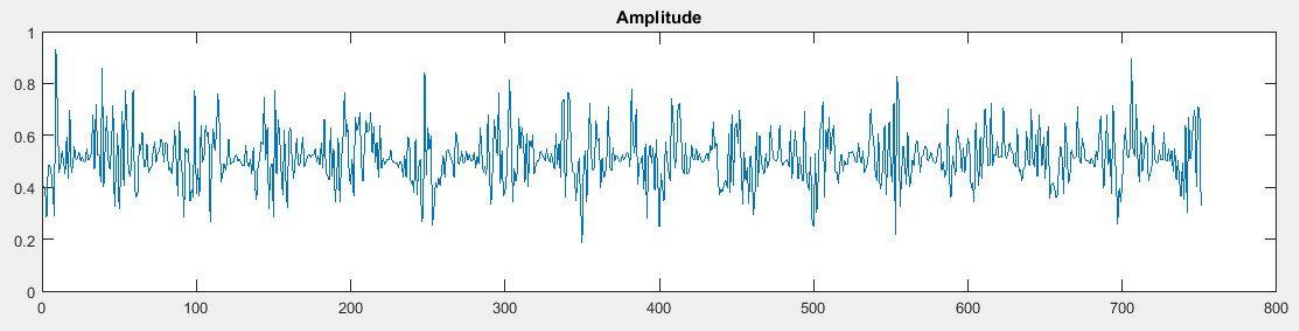

Fig. 4 MATLAB Simulation of the extracted amplitude when metal present

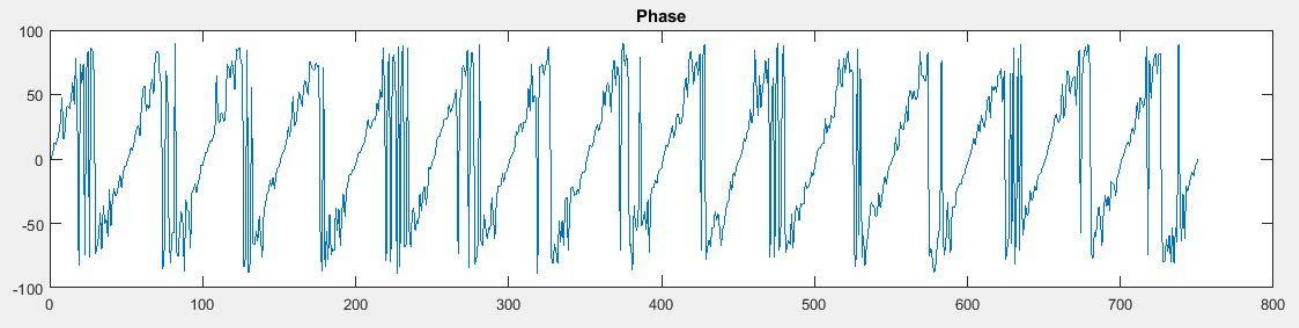

Fig. 5 MATLAB Simulation of the extracted phase when metal present

IV. CONCLUSIONS

From this paper we see that, a study on various metal detectors which are used now a days in order to detect the presence of metal in any of industry. We have also seen various methods which are used in detecting the amplitude and phase of the received signal theoretically and through ADC. We have compared the different methods by looking at their SNR and chose the best among them. These features can further be used in classifying a metal from a non-metal (pure product) and studying its characteristics.

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